

Particles 007 Quarks

19 February 2020 10:45

Quarks form the basic building blocks - at the moment.... Evidence from the scattering of high electrons from protons suggested that inside the proton where in fact three concentrations of charge...

Several types, and they have anti quarks too
 Up (u) and down (d) are all you need to make protons and neutrons
 Strange (s) is a third type

Strangeness

- another quantum number and is conserved - but not always
- only take certain values, like baryon number
- Strange particles, eg kaons, are created in the **strong** interaction and decay via the **weak**.
- Strangeness is conserved in the strong but not in the weak
- This means that strange particles are created in pairs (K+ and K-) so the overall strangeness is 0 and is conserved.

Quarks and Antiquarks

Note the fractional charges and baryon numbers (but integer strangeness)

QUARKS	Name	Symbol	Charge	Baryon number	Strangeness
	up	u	$+\frac{2}{3}$	$+\frac{1}{3}$	0
	down	d	$-\frac{1}{3}$	$+\frac{1}{3}$	0
	strange	s	$-\frac{1}{3}$	$+\frac{1}{3}$	-1

ANTIQUARKS	Name	Symbol	Charge	Baryon number	Strangeness
	anti-up	\bar{u}	$-\frac{2}{3}$	$-\frac{1}{3}$	0
	anti-down	\bar{d}	$+\frac{1}{3}$	$-\frac{1}{3}$	0
	anti-strange	\bar{s}	$+\frac{1}{3}$	$-\frac{1}{3}$	+1

“up” quarks
 $+\frac{2}{3}e$ $+\frac{2}{3}e$
 “down” quark
 $-\frac{1}{3}e$
 proton $q = +e$
 $+\frac{2}{3}e$ $-\frac{1}{3}e$
 $-\frac{1}{3}e$
 neutron $q = 0$

This shows the quark arrangements in protons and neutrons. Note how the charges add up to the charges on the proton and neutron.

proton u u d neutron d d u
 antiproton \bar{u} \bar{u} \bar{d} antineutron \bar{d} \bar{d} \bar{u}

See here how the anti versions have simply got anti quarks. You should see that the baryon and charges add up.

Mesons

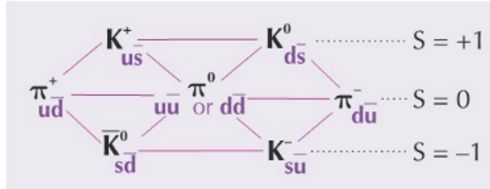
These turn out to be a quark and an antiquark pair. This leads to some beautiful patterns.... And as ever with patterns there are/were gaps which lead to predictions/discovery of new mesons.

$u, d, s, \bar{u}, \bar{d}, \bar{s}$

$u\bar{u}, u\bar{d}, u\bar{s}$

$d\bar{u}, d\bar{d}, d\bar{s}$

$s\bar{u}, s\bar{d}, s\bar{s}$



This table is incomplete - you can see that some are missing from it, clearly the table is not complete, but you get the idea.

We now know enough to consider what is going on in beta minus decay.

- Caused by the weak interaction
- A neutron turns into a proton
- In the proton one down turns into one up quark
- An electron and an anti electron neutrino are given off

And in beta plus decay.

- Caused by the weak interaction
- A proton turns into a neutron
- In the neutron one up turns into one down quark
- A positron and an electron neutrino are given off

see...
} a symmetry here!

If you ever wondered if a neutron was a proton & an electron stuck together you were not alone, but you were wrong. Reality is more complex.